1.3 Constraints for Analysis

- The databases (Auxiliary Broadcast 6875-7125 MHz band and the CARS/Auxiliary Broadcast 12.75-13.25 GHz bands) containing the fixed point-to-point records used in this analysis was constructed from the information stated on the FCC application for authorization (FCC Form 313). Earlier versions of the FCC Form 313 did not require applicants to specifically indicate the geographic coordinates, ground elevation, antenna centerline height above ground or fixed losses at the receive station. Therefore, the database contains inaccuracies with respect to these records. These inaccuracies effect the accuracy of the calculated tilt angle of the terrestrial receive antenna. It is not believed that these inaccuracies will result in significant errors.

- Also, since the interference objective into video receivers are based upon Carrier-to-Interference ratios and both signals will experience the same fixed losses between the receive antenna and the receiver, the carrier to interference ratio calculated at the receive antenna will not be affected by the possible inaccuracy of receiver fixed losses.

2.0 Methodology

2.1 Downlink

2.1.1 General

The approach undertaken in this study is to determine from a practical point of view if the Globalstar satellite downlink with a power flux density ranging from a maximum of -164.5 dBW/m^2/4 kHz to a minimum of -173.5 dBW/m^2/4 kHz will cause unacceptable interference into terrestrial microwave receivers operating in the bands 6425 - 6525 MHz, 6525 - 6875 MHz, 6875 - 7125 MHz and 12750 - 13250 MHz bands.

For each band, site locations were selected in congested terrestrial areas with varying terrain features and climate zones. For these selected areas, the Comsearch maintained database was searched and all existing records for each frequency band were retrieved.

Once the records were retrieved, interference calculations were performed based upon the methodology described in Section 2.1.3. The computed interfering power levels were then compared to the derived objectives in Section 2.1.2. All the analyzed cases were then compiled, tabulated, and reported in the appropriate Appendix. The relevant appendices to the downlink analyses are A,B,C and D. The results and conclusions of these analyses are reported in Sections 3.1 and 4.1 of the main report.

The electronic news gathering (ENG) analysis had to follow a different approach due to the lack of data that adequately describe the necessary ENG geographic and other operational parameters. The analyses assumed four ENG configurations. For every configuration, we varied the experienced obstruction loss and evaluated the interference impact of a Globalstar satellite. The ENG applicable interference objectives are presented in Section 2.1.2.1. The computation of the interference levels followed the method introduced in Section 2.1.3 and was carried out in Appendix D.

2.1.2 Derivation of the Required Interference Objectives for Downlink Analyses in the 6425-6525 MHz, 6525-6875 MHz, 6785-7125 MHz and 12.75-13.25 GHz Frequency Bands

The Federal Communications Commission [1][1] specifies the guidelines and rules for spectrum sharing and for the interference protection criteria. The FCC recognizes the Electronic Industries Association (EIA) as a standard body which interference objectives could be used in spectrum sharing studies.[1], [2] and [3].[2]

The EIA, has established interference criteria initially for the Private Operational-Fixed Microwave Service (OFS). Thereafter, additional criteria was developed for additional services which share the OFS bands, such as the Auxiliary Broadcast Service and the Cable Television Relay Service (CARS). Auxiliary Broadcast and CARS share several bands with OFS including 6425 - 6525 MHz and 12.75 - 13.25 GHz.

The National Spectrum Managers Association, NSMA, also issues interference protection criteria for the Common Carrier Radio Service. The NSMA has compiled the earlier criteria used and agreed upon as a de facto standard by most common carriers in the United States. Currently, there are joint working groups between the NSMA and the TIA. Note also that 6425 - 6525 MHz is shared on an equal basis by the OFS, CARS, Common Carriers and Auxiliary Broadcast users.

Mainly we shall use the EIA's interference criteria as given in [4]. Where the EIA does not have an established criteria, we shall extend the EIA's method and compare the results to that of the NSMA's [5], [6] for quality assurance. We shall also indicate where the NSMA's criteria is equal to the EIA's.

2.1.2.1 Interference into FM/Video Systems

The method given in [4,pp 128-129] for FM/Video protection requirements from digital signals is directly applicable to this situation. Globalstar's 16.5 MHz direct sequence spread spectrum signal appears as a flat broadband noise source. The expected Globalstar's satellite power spectral density is shown in Figure 2.1.2.1-1 and fits the EIA's assumption of the digital signal's

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1 The reference [] referred to in this section can be found on Page 62.

2 The EIA is currently known by Telecommunications Industry Assoication (TIA)/Electronics Industry Association (EIA).

spectral density.

The following is a complete account of the method we shall utilize as given in [4,pp 128-129].

Globalstar's power spectral density shown in Figure 2.1.2.1-1 , fits the required criteria.

The video signal-to-noise ratio is given by:

$$S/N = C/N + E + W + L + 10\log(B_{nif}/2f_m) + 20\log(f/f_m) + 4.8 \text{ (dB)} \quad (2\text{-}1)$$

where,

S:	demodulated video level (dBm)
N:	noise power over the IF bandwidth, B_{nif} (dBm)
C:	receiver carrier level (dBm)
f:	peak video deviation (Hz)
f_m:	highest video modulation signal (Hz)
E:	improvement due to emphasis (dB)
W:	improvement due to weighting (dB)
L:	peak-to-peak of picture portion of video signal to rms noise conversion

E+W=9.2 for CCIR 405-1 emphasis and EIA weighting L=6.1 dB.

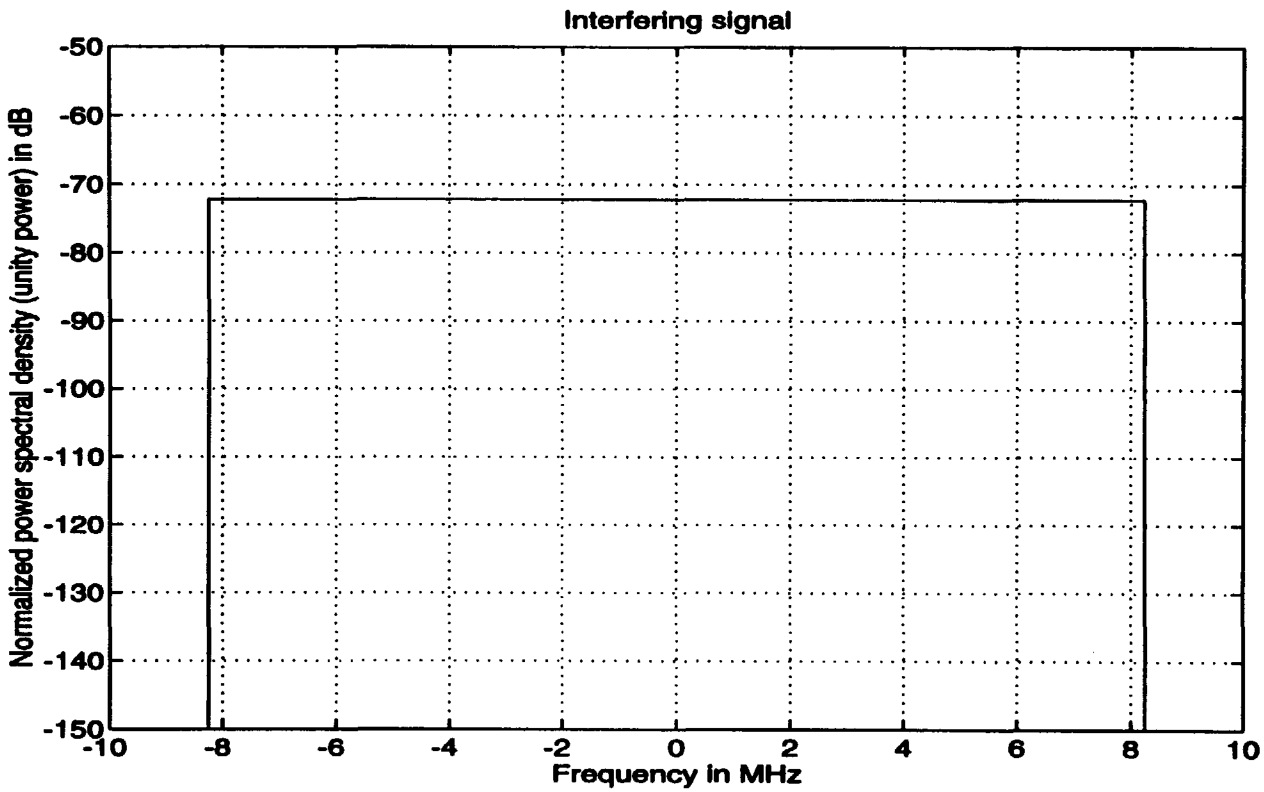

Figure 2.1.2.1-1: Globalstar's Normalized Power Spectral Density Based on -164.5 dBW/4 kHz.

The video parameters are given in Table 2.1.2.1-1.

Band	Service	Video Parameters
6425 - 6525 MHz[1]	Auxiliary Broadcast (ENG)	f = 4 MHz f_m = 4.2 MHz (NTSC Video) B_{nif} = 20 MHz
6525 - 6875 MHz	Private Operational-Fixed Microwave[2]	f = 4 MHz f_m = 4.2 MHz (NTSC Video) B_{nif} = 25 MHz
6875 - 7125 MHz	Auxiliary Broadcast (ENG)	f = 4 MHz f_m = 4.2 MHz (NTSC Video) B_{nif} = 20 MHz
	Auxiliary Broadcast (Fixed Relay)	f = 4 MHz f_m = 4.2 MHz (NTSC Video) B_{nif} = 25 MHz
12.75 - 13.25 GHz	ALL	f = 4 MHz f_m = 4.2 MHz (NTSC Video) B_{nif} = 25 MHz

Table 2.1.2.1-1
FM-Video Parameters

Note 1: Interference objective should conform to [5] and [6]. References [5] and [6] are considered the common carrier's industry standards.
Note 2: Systems operating with waivers.

2.1.2.1.1 Short Haul C/I Objectives

The EIA [4, pp 129] utilizes short haul objectives since the treatment was primarily intended for the 12.75 - 13.25 GHz band. The short haul objective is S/N = 67 dB [7]. Additional degradation protection by no more than 0.5[4], dB requires a total of 77 dB S/N.

Therefore, for short haul FM-Video

$$C/I = S/N - 24.44 \text{ for } B_{nif} = 25 \text{ MHz} \quad (2\text{-}2a)$$

$$C/I = S/N - 23.44 \text{ for } B_{nif} = 20 \text{ MHz} \quad (2\text{-}2b)$$

$$C/I = 77 - 24.44 = 52.56 \approx 53 \text{ dB} \quad (2\text{-}3a)$$

$$C/I = 77 - 23.44 = 53.56 \approx 54 \text{ dB} \quad (2\text{-}3b)$$

Utilizing short haul objectives, [5] and [6], reflect a co-channel C/I objective of 54 dB for a 135 Mbps 64 QAM signal occupying 30 MHz, interfering into a 25 MHz FM-Video. These computations were done for the 5925 - 6425 MHz common carrier band. The 135 Mbps 64 QAM normalized power spectral density within ± 10 MHz of the central carrier, resembles closely that of the 16.5 MHz satellites signal given in Figure 2.1.2.1-1.

According to the EIA[7, pp 5], a short haul relay system, by definition, is where service can be accomplished by one hop. Furthermore, [7, pp 5] specifies that a studio-to-transmitter link (STL) and television pick-up fit under the short haul category. Based on [4], operation in the 12.75 - 13.25 GHz fits the short haul criteria.

2.1.2.1.2 <u>Long Haul C/I Objectives</u>

The EIA-250-B [7], specifies for a long haul terrestrial relay system, a video signal-to-noise ratio of 54 dB (within 10 kHz - 500 MHz). The video signal-to-noise ratio is defined as the ratio of the total luminance signal level (100 IRE units) to the weighted RMS noise level [7, pp 30].

Unfortunately, long haul objectives were not specified in [4]. The objectives given herein are concluded from a combinational approach of [4], [5], [6] and [7].

Utilizing long haul objectives, [5] shows a co-channel interference of 64 dB C/I. The interferer is a 30 MHz 135 Mbps 64 QAM signal, resembling in its normalized power spectral density that of a Globalstar's satellite 16.5 MHz signal. The interfered with system is a 25 MHz FM-Video.

In deriving the long haul objective in [6], a required peak-to-peak signal-to-weighted-interference noise of 92 dB is used. The 92 dB baseband objective is based on an end-to-end overall 53 dB peak-to-peak signal-to-weighted-interference noise.

The components of the 92 dB peak-to-peak signal-to-weighted-interference noise are as follows [6, pp 16 - 17]:

53 dB	peak-to-peak signal-to-weighted-interference noise.
3 dB	contribution by the local network and toll-connecting system.
6 dB	interference supressed will be 6 dB below the noise level.
30.5 dB	1134 equally-weighted interference added over 4,000 miles long haul system (207 same route, 308 junction, 156 foreign-system).
92.5 dB	total peak-to-peak signal-to-weighted interference noise. Note that [6] utilizes a rounded down figure of 92 dB.

Extending [5] method in allocating the necessary S/N to sustain degradation over a long haul system, we obtain:

54 dB ratio of total luminance signal level to the weighted RMS

noise level [7, pp 30] .

3 dB local network and toll-connecting system contribution.

6 dB interference suppressed 6 dB below noise level.

30 dB a total of approximately 1,000 equal exposures over 4,000 miles for a long haul system or a system containing well over 10 repeater stations. THe EIA ([7, pp 5] specifies long haul as 150 repeater system)

93 dB total

Applying 93 dB to equations (2-2a) and (2-2b),

$$C/I = 93 - 24.44 = 68.56 \approx 69 \text{ dB for 25 MHz } B_{nif} \tag{2-4a}$$

$$C/I = 93 - 23.44 = 69.56 \approx 70 \text{ dB for 20 MHz } B_{nif} \tag{2-4b}$$

These C/I levels of 69 dB and 70 dB concluded from the EIA's method compared with the NSMA's S/N protection criteria are stringent, especially considering that long haul common carriers utilize an equivalent criteria of only 64 dB [5 and 6] thus, we need a further investigation of this conclusion.

Furthermore, it is worthy to note that by definition the EIA [7, pp 5] defines long haul systems as those requiring well over 10 repeater stations to relay the signal between two terminals. Reference [7, pp 5] adds that, a cross country or interstate relay system of up to 150 repeaters would be considered a long haul terrestrial relay system. This definition is equivalent to the NSMA's [6] definition of a long haul relay system.

2.1.2.1.3 Medium Haul C/I Objectives

The EIA reference [7, pp 5] defines medium haul as a system which employs as many as ten repeater stations. With an average path length of 25 miles, the definition in [7] becomes equivalent to that in [6] for a short haul radio relay system (250 mile system).

Reference [6] add-on's to the S/N to prevent degradation is as follows:

53 dB peak-to-peak signal-to-weighted interference noise.

3 dB contribution of local network and toll connecting system.

6 dB interference maintained 6 dB below the noise.

20 dB the effect of 100 equally weighted exposures.

82 dB total

Noting that in Reference [7, pp 30], the medium haul S/N is 60 dB, and applying similar add-on's as above, the resultant S/N is:

$$60 + (3 + 6 + 20) = 89 \text{ dB} \qquad (2\text{-}5)$$

Equation (2-5) specifies ratio of total luminance signal level to the weighted RMS noise level.

Applying the 89 dB to equation (2-2a) and (2-2b)

$$89 - 24.44 = 64.56 \approx 65 \text{ dB for 25 MHz } B_{nif} \qquad (2\text{-}6a)$$

$$89 - 23.44 = 65.56 \approx 66 \text{ dB for 20 MHz } B_{nif} \qquad (2\text{-}6b)$$

Note that these results are closer to the 64 dB objectives for common carrier long haul systems [5]. We feel it is conservative to apply the 65/66 dB criteria to medium and long haul systems. One may elect to use 64 dB as well.

2.1.2.1.4 Summary of FM/Video Interference Objectives

In summary, we suggest using Table 2.1.2.1.4-1 was a recommendation to coordinate the Globalstar 16.5 MHz signals on a downlink with the FM-Video in the 6425 - 6525 MHz, 6525 - 6875 MHz, 6875 - 7125 MHz, and 12.75 - 13.25 GHz bands.

System Type	Frequency Band			
	6425 - 6525 MHz	6525 - 6875 MHz	6875 - 7125 MHz	12.75 - 13.25 GHz
Short Haul (1)	54/53	54/53	54/53	54/53
Medium Haul (1)	66/65	66/65	66/65	–
Long Haul (1)	66/65 (2)	66/65 (2)	66/65 (2)	–

Table 2.1.2.1.4-1
Suggested C/I Protection Ratio for FM Video Systems

AA/BB: AA is applicable to 25 MHz bandwidth.
BB is applicable to 20 MHz bandwidth.

Note (1): as defined by EIA RS-250-B [7, pp5]
Note (2): 69/70 dB were not selected due to the wide variation with the common carrier long haul standards of 64 dB [5] and [6].

2.1.2.2 C/I for Vestigial-Side-Band Amplitude Modulated (VSB-AM) Video

In the 12.75 - 13.25 GHz band, there exists very heavy utilization of VSB-AM video by the CARS [2] operators. The EIA [4, pp 146] specifies the method to be utilized in computing the C/I (dB) from a digital interferer into VSB-AM. The governing equation is as follows [4, pp 146]:

$$C/I = 65 - 10 \log (B_d/B_{ov}) \qquad (2-7)$$

where:

B_d: digital channel bandwidth in kHz.

B_{ov}: overlap bandwidth in kHz, $100 \leq B_{ov} \leq 6{,}000$
(Note that the VSB-AM signal bandwidth is 6,000 kHz)

Therefore, the required C/I from a Globalstar 16.5 MHz flat signal is:

$$C/I = 65 - 10 \log \left(\frac{16{,}500}{6{,}000}\right) = 60.61 \; dB \approx 61 \; (dB) \qquad (2-8)$$

Further note that VSB-AM applications in the 12.75 - 13.25 GHz are considered short haul [7, pp 5].

2.1.2.3 Interference Objectives for FM/FDM Systems - Applicable to the 6525 - 6875 MHz Band

The Federal Communications Commission recognizes [3, §94.63(d)(2)] the Electronics Industries Association (EIA) as a standards body for the interference objectives required to fulfill the interference criteria set forth for the Operational-Fixed Microwave Service (OFS) in [3, §94.63].

The EIA's latest draft document [8], outlines a robust and correct method in assessing the interference objectives required to FM/FDM systems from digital interferers. The method in [8 Appendix A], is applicable to the Globalstar direct sequence spread spectrum signal. It is also applicable to the satellite as given by a uniform flat 16.5 MHz power spectral density (see Figure 2.1.2.1-1). Figure 2.1.2.1-1 coincides within 1 or 2 dB the actual normalized power spectral density of 13 1.3 MHz direct sequence spread spectrum signals contained on a 16.5 MHz transponder channel. We shall assume Figure 2.1.2.1-1 as the power spectral density for the analysis.

Table 2.1.2.3-1 shows the parameters used as inputs for the generated C/I (dB) curves.

Figures 2.1.2.3-1 through 2.1.2.3-9 show the results of the required protection ratios for the parameters given in Table 2.1.2.3-1. Note that Figures 2.1.2.3-4 through 2.1.2.3-9 are applicable to the OFS operations. All of the figures indicate that the co-channel case requires the highest C/I (dB). Thus we have adopted the co-channel objective for our analysis. Also, note that the co-channel C/I satisfies the 1 dB threshold degradation requirements.

TABLE 2.1.2.3-1 : **FM-FDM Systems' Parameters Used in Generating the C/I Objectives**

	2400 Channel	1800 Channel	900 Channel	780 Channel	600 Channel	480 Channel	300 Channel (10 MHz)	300 Channel (5 MHz)	120 Channel
Per Channel Load (dBm0)	-19.6	-19.6	-19.6	-19.6	-15.6	-15.6	-15.6	-19.6	-15.6
Total RMS Deviation (KHz)	718	890	899	409	610	459	363	317	273
RF Bandwidth (MHz)	30	20	20	10	10	10	10	5	10
Baseband Noise Objective (pWp0)	5	5	5	5	5	5	5	5	5

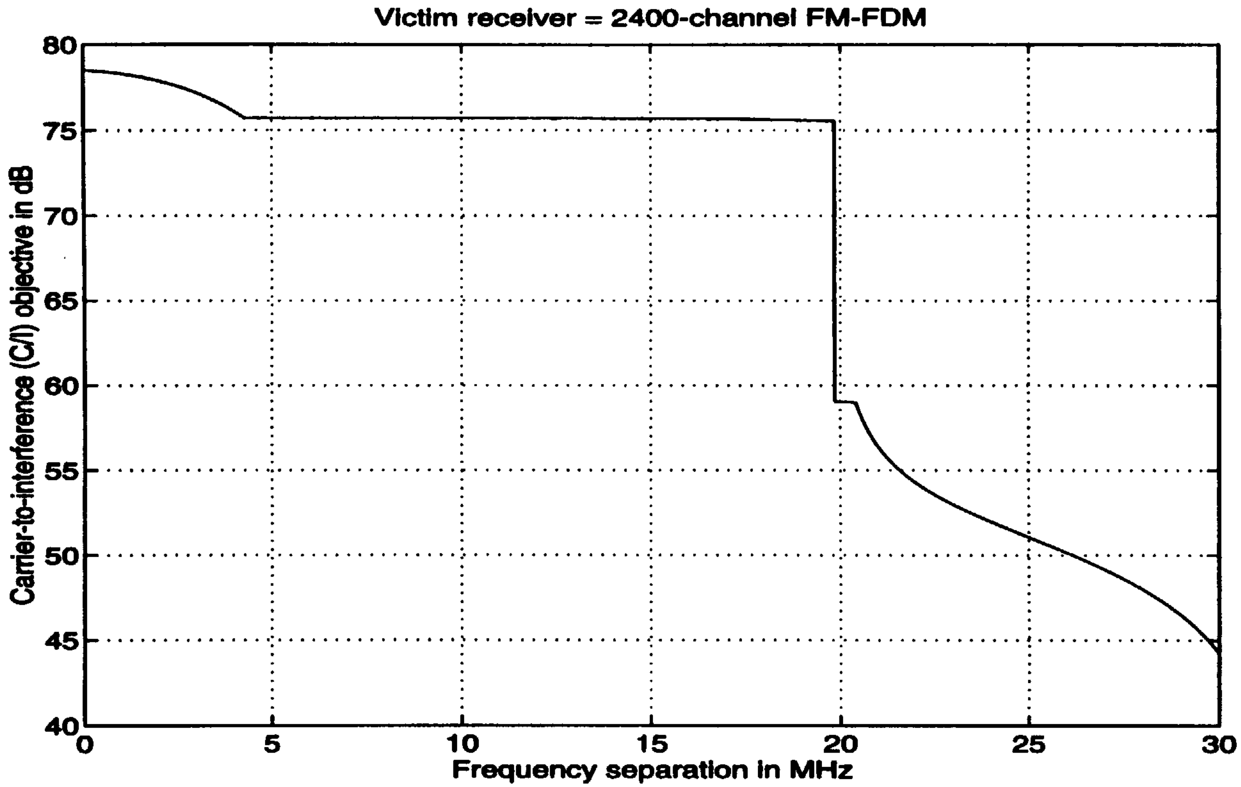

FIGURE 2.1.2.3-1: Required C/I (dB) Protection Ratio for 2400-Channel FM-FDM Receiver.

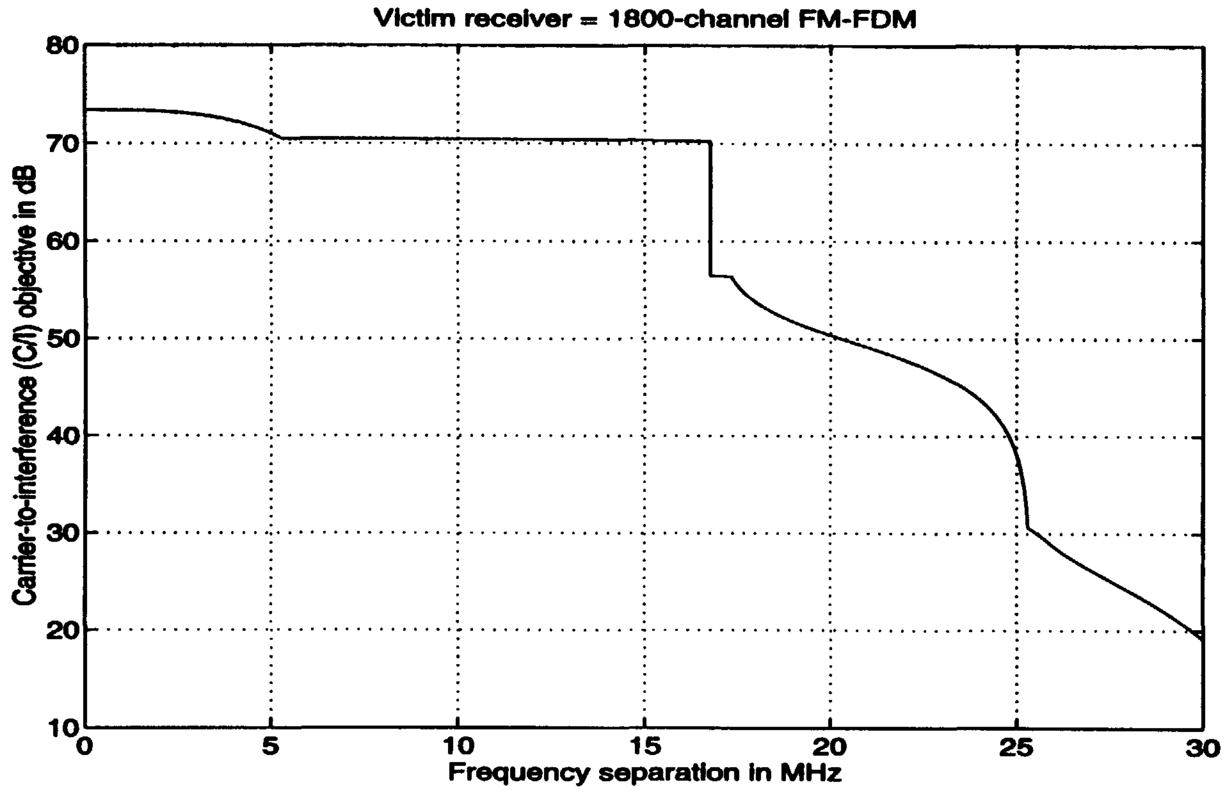

FIGURE 2.1.2.3-2: Required C/I (dB) Protection Ratio for 1800-Channel FM-FDM Receiver.

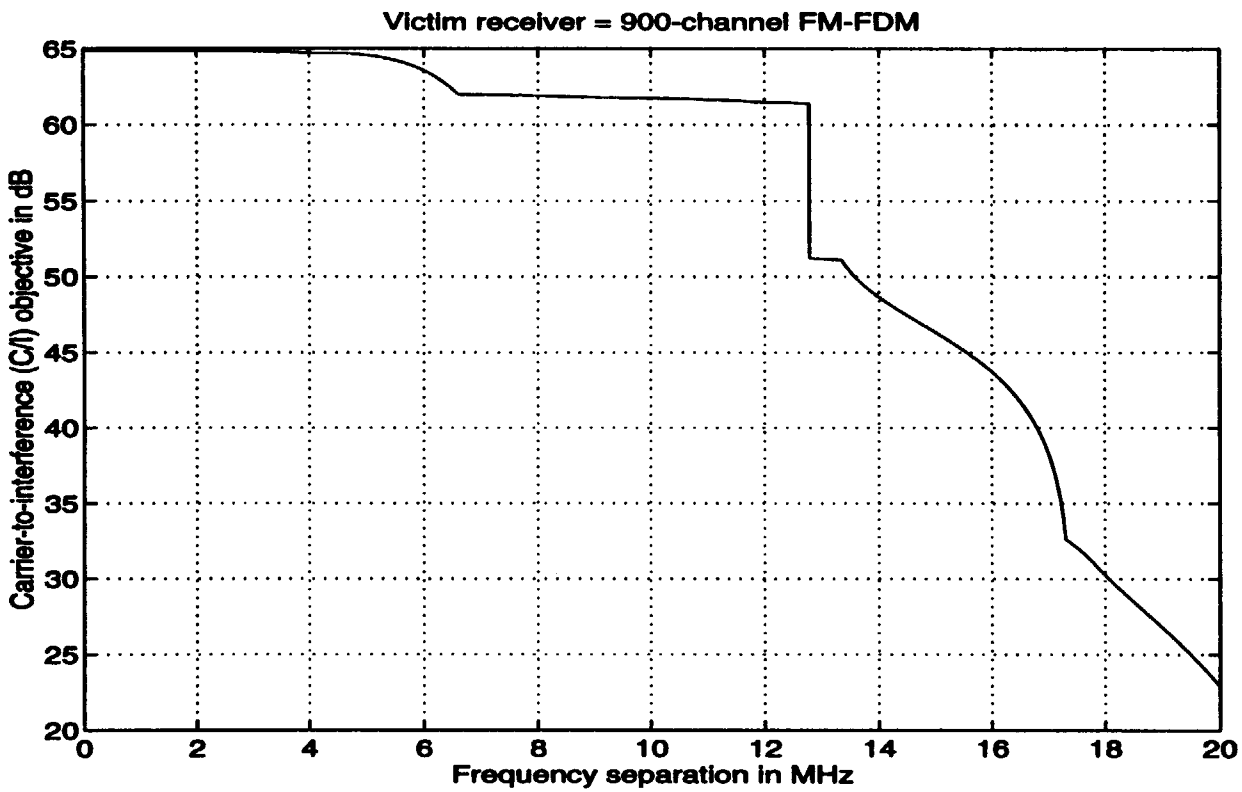

FIGURE 2.1.2.3-3: Required C/I (dB) Protection Ratio for 900-Channel FM-FDM Receiver.

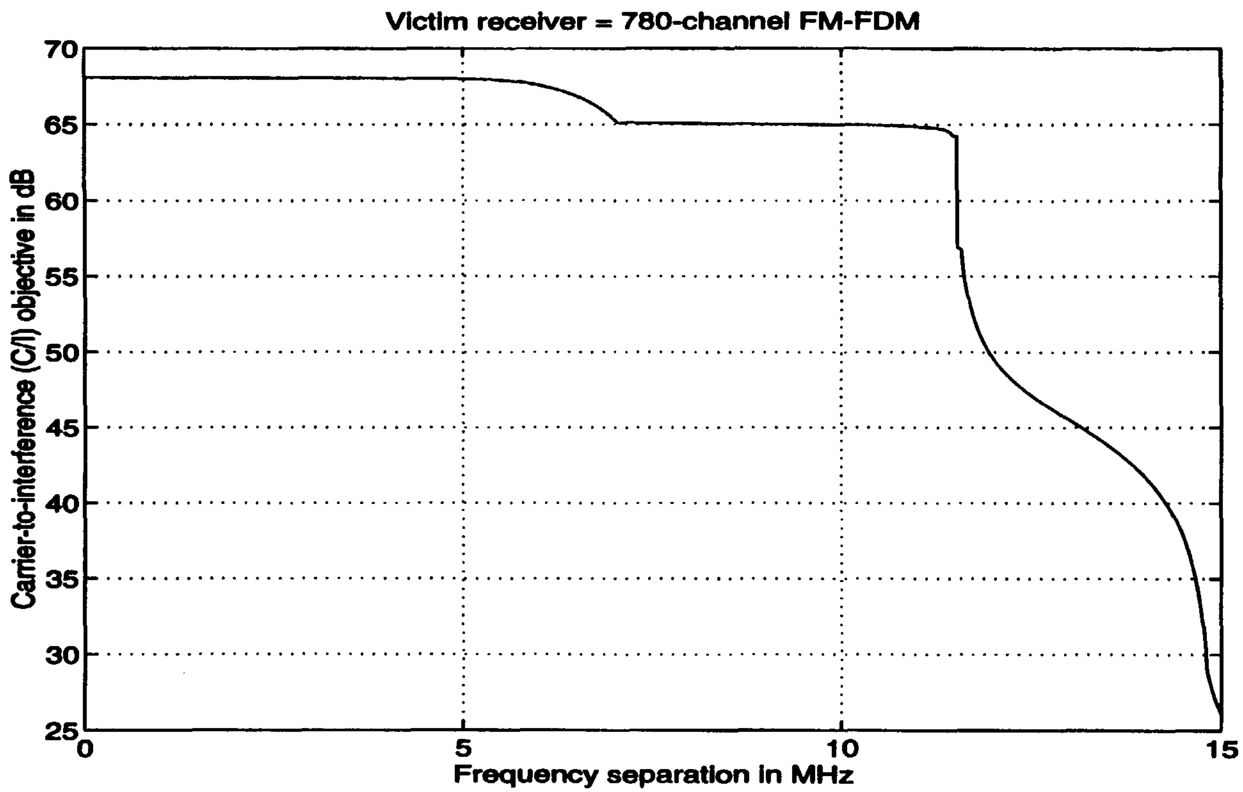

FIGURE 2.1.2.3-4 : Required C/I (dB) Protection Ratio for 780-Channel FM-FDM Receiver.

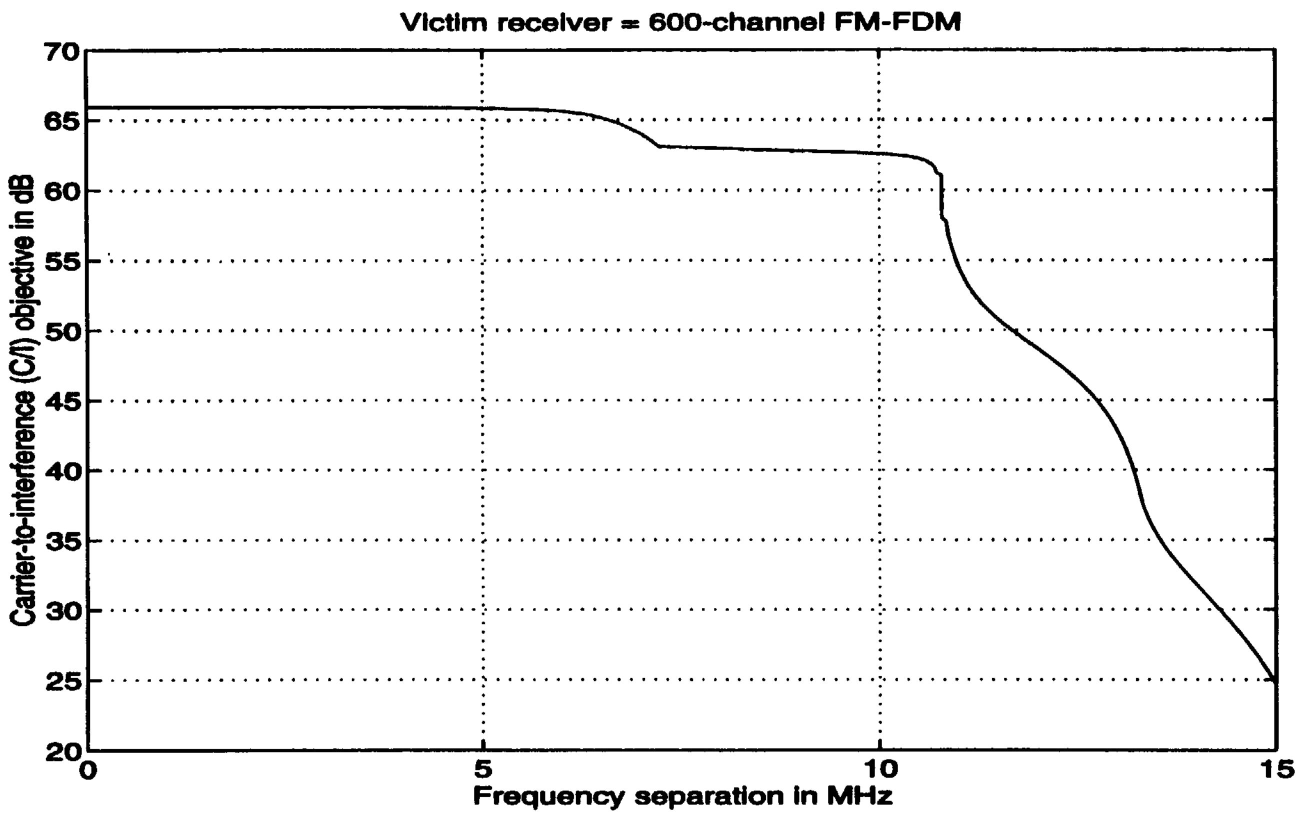

FIGURE 2.1.2.3-5: Required C/I (dB) Protection Ratio for 600-Channel (5 MHz) FM-FDM Receiver

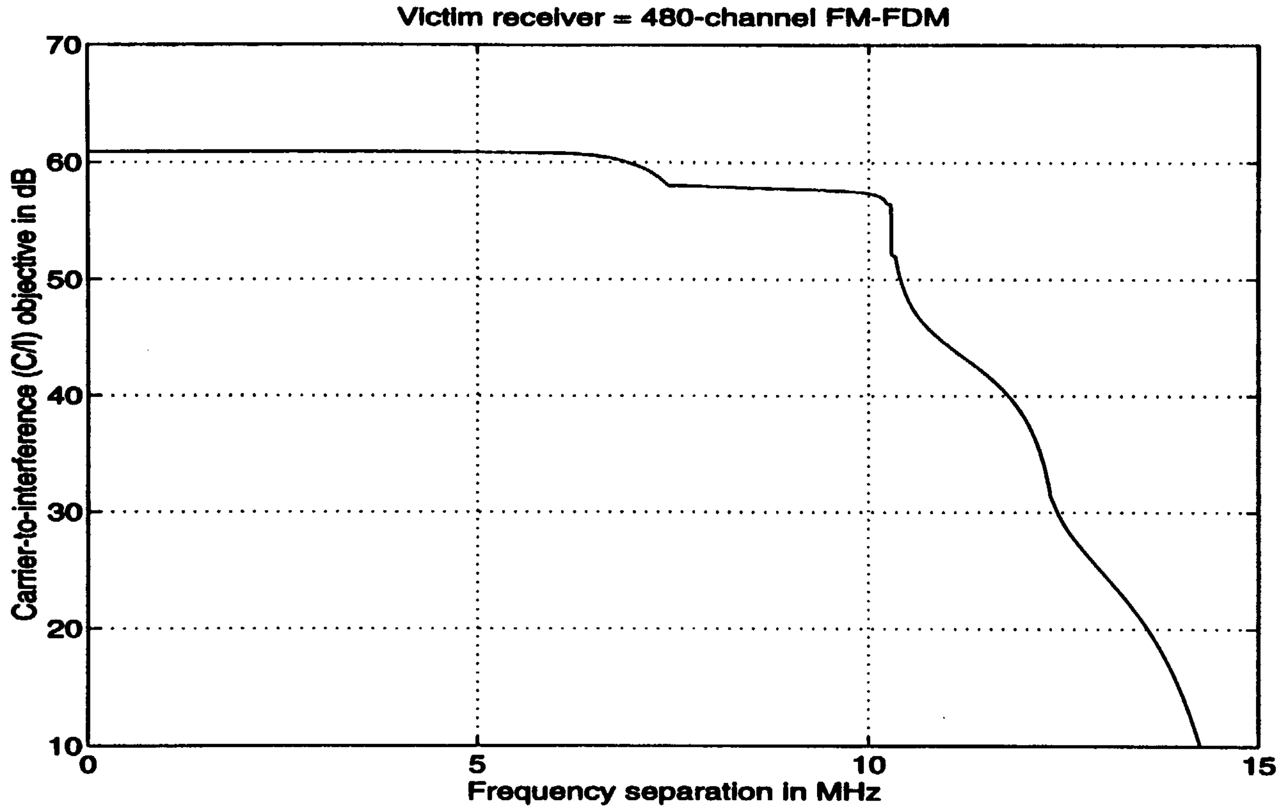

FIGURE 2.1.2.3-6: Required C/I (dB) Protection Ratio for 480-Channel FM-FDM Receiver

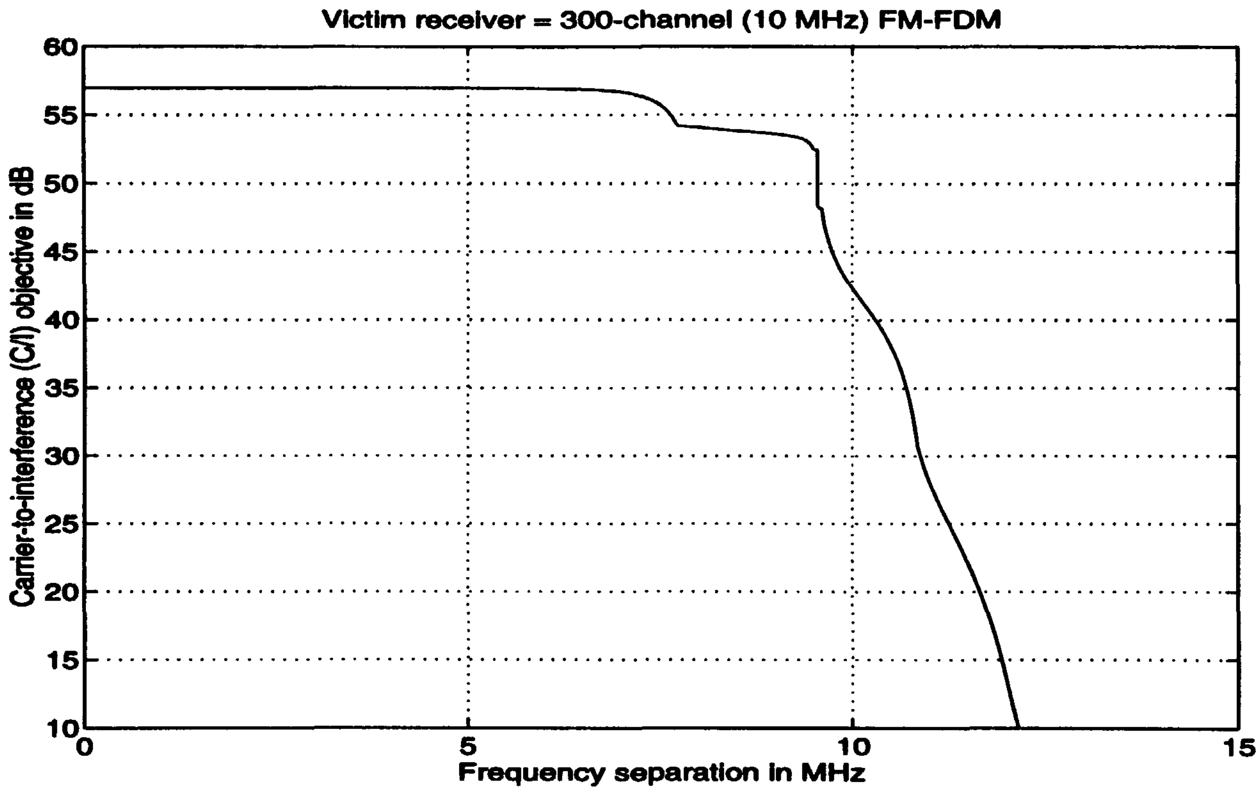

FIGURE 2.1.2.3-7: Required C/I (dB) Protection Ratio for 300-Channel (10 MHz) FM-FDM Receiver.

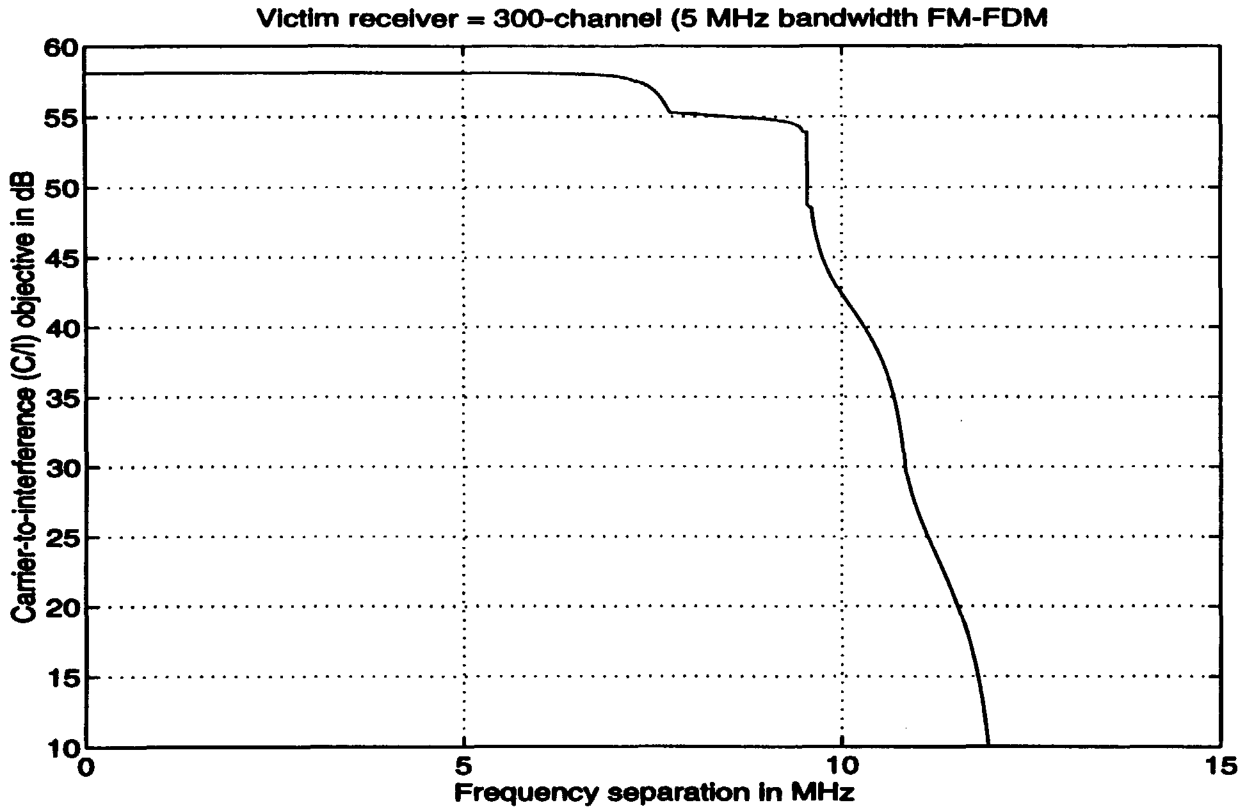

FIGURE 2.1.2.3-8: Required C/I (dB) Protection Ratio for 300-Channel (5 MHz) FM-FDM Receiver.

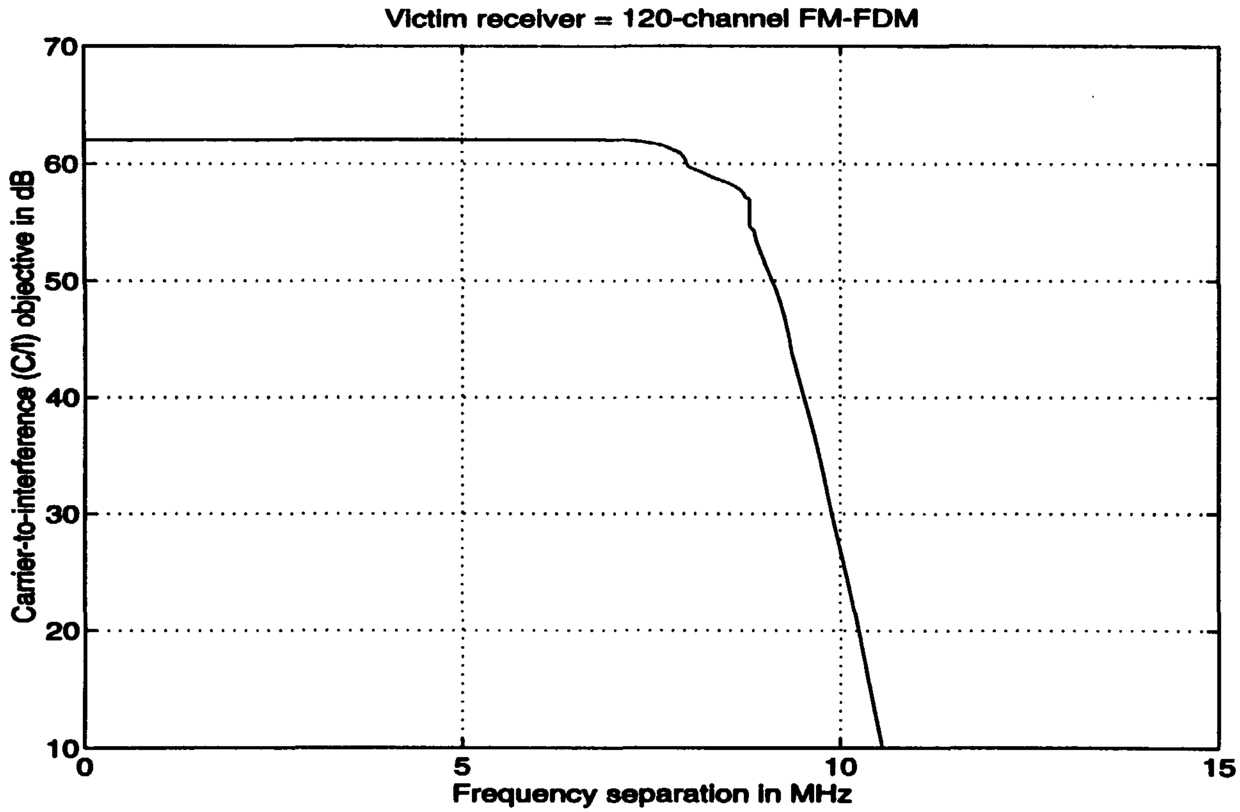

FIGURE 2.1.2.3-9: Required C/I (dB) Protection Ratio for 120-Channel FM-FDM Receiver.

2.1.2.4 Interference Objectives for Digital Systems - Applicable to All Bands

The EIA's presents a more expanded and more comprehensive treatment of the required method necessary to protect digital microwave radios [8].

The required interference objectives, from digital or analog signals, is derived from the threshold-to-interference (T/I) power ratio. The threshold, known as a static, non-fading threshold, is defined for purposes of interference analysis as that manually faded (with attenuators) receive carrier level that produces a Bit Error Rate (BER) of 10^{-6}. The EIA shows an extensive table of the required (T/I) for different modulations [8, pp B-5]. A subset of that table is given by Table 2.1.2.4-1 below.

Modulation	Typical Co-Channel T/I (dB)	Spectrum Bandwidth (MHz)
4L FSK	23.6	6.5
25QPR	26.2	4.1
49QPR	28.4	4.8
32QAM	30.0	2.6
64QAM	33.1	7.5
256QAM	39.1	2.4

Table 2.1.2.4-1
Typical Digital Microwave
T/I (dB) Requirements [8, pp B-5]

The relationship between (T/I) (dB) and the tolerate interference level is as follows:

$$(T/I) = T_s - I_o \quad \text{(dB)} \qquad (2\text{-}9)$$

where,

T_s is that manually faded (with attenuators) receive carrier level that produces a BER of 10^{-6} (dBm).

I_o is the interference power level that is required at the input to the receiver to maintain the prescribed BER (dBm).

(T/I) is the ratio of desired faded carrier to undesired carrier power that degrades the digital receiver static and dynamic (outage) thresholds by 1 dB [8, pp B-1] (dB). The (T/I) is a laboratory measured value.

From Equation (2-9), the tolerated interference carrier power is

$$I_o = T_s - (T/I) \quad (dBm) \tag{2-10}$$

Our approach does not consider the implication of the required I_o on the path's composite fade margin or reliability.

The (T/I) is obtained upon injecting a tone or an identical signal (to that transmitted by the desired transmitter) into the receiver. This (T/I) holds true for the Globalstar's power spectral density since the Globalstar resembles some of the current densities utilized in the OFS bands. Note that the deduced (T/I) is based on the total power admitted by the receivers' passband.

2.1.3 Derivation of Analyzed Power Levels

2.1.3.1 Maximum Coupling Between Terrestrial Antenna and a Globalstar Satellite

The Globalstar satellite power flux density, PFD at a distance, R, is given by:

$$PFD = \frac{P_s}{4\pi R^2} \qquad w/m^2 \qquad (2\text{-}11)$$

where

P_s is the effective radiated power from the satellite (watts)

R is the range or distance from the satellite (meters)

The interference power seen by a terrestrial receiver is given by:

$$I_R = PFD\ [(\lambda^2 G_R)/(4\pi FL)]B \qquad (\text{watts}) \qquad (2\text{-}12)$$

where:

λ: wavelength in meters (λ - 300/f, where f is the frequency in MHz).

I_R: interference power at the terrestrial receiver input in watts.

G_R: terrestrial antenna gain in the direction of the satellite.

FL: fixed losses at the terrestrial receiver including transmission line, attenuator, and branching losses.

B: terrestrial receiver bandwidth in Hz.

Note that the antenna effective area was solved as a function of G_R and substituted in 2-12.

Taking the logarithm of (2-12) and noting that the PFD is -164.5 dBW/4 kHz/m^2,

$$I_R = -164.5 + G_R + 10\ \log\ (\lambda^2/4\pi) - FL + 10\ \log\ (B/4)\ (\text{dBW}) \qquad (2\text{-}13)$$

$$I_R = -134.5 + G_R + 10\ \log\ (\lambda^2/4\pi) - FL + 10\ \log\ (B/4)\ (\text{dBm}) \qquad (2\text{-}14)$$

Note that B is the bandwidth in kHz in both (2-13) and (2-14).

The terrestrial carrier level is given by:

$$C = ERP_T - FSL + G - FL \qquad (\text{dBm}) \qquad (2\text{-}15)$$